

**Before the
Federal Communications Commission
Washington, DC 20554**

In the Matter of)	
)	
Facilitating Opportunities for Flexible,)	ET Docket No. 03-108
Efficient, and Reliable Spectrum Use)	
Employing Cognitive Radio Technologies)	

REPLY COMMENTS OF AT&T WIRELESS SERVICES, INC.

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Pursuant to Section 1.415 of the Commission’s rules,¹ AT&T Wireless Services, Inc. (“AT&T Wireless”) respectfully submits these reply comments to the *Notice of Proposed Rulemaking and Order* (“NPRM”) in the above-captioned proceeding.²

INTRODUCTION

Cognitive radio (“CR”) technology is already being used in many radio services and will continue to develop rapidly in response to greater demands for spectrum resources and enhanced customer services. The Commission’s attempts to encourage CR development, while laudable, are overshadowed by the potential negative impacts on existing users of the spectrum—both licensed and unlicensed. Specifically, sharing between licensees of the Commercial Mobile Radio Service (“CMRS”) and unlicensed CR devices appears extremely doubtful given the large numbers of existing subscribers, the inherent challenges of mobility and the intensive nature of CMRS spectrum use coupled with the technical challenges of spectrum sensing. In this case, rather than forcing CMRS subscribers to share spectrum with unlicensed CR devices on a “non-voluntary” basis, the Commission should allow secondary market transactions to arrange such sharing, if and when it ever becomes feasible. In the interim, unlicensed CRs could be tested in (new or existing) spectrum identified specifically for unlicensed use. In addition, it appears that

¹ 47 C.F.R. §1.415(c) (2002).

² *Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies*, ET Docket No. 03-108, *Notice of Proposed Rulemaking and Order*, 18 FCC Rcd 26859 (2003).

the Commission's proposals for raising power limits where spectrum is "unused" need additional clarification as does its proposals on security requirements for software defined radios ("SDRs"). Until such concerns are addressed, the Commission should not adopt the changes it proposes.

I. COGNITIVE RADIOS CAN IMPROVE ACCESS AND EFFICIENCY, BUT ARE NOT A PANACEA.

The Commission has identified many of the benefits that CRs can bring in terms of managing spectrum more efficiently. As the comments demonstrate, CRs—at least in a primitive stage—are already in widespread use in many radiocommunication applications.³ Within the CMRS industry, basic CRs are rapidly finding their way into base stations and mobile devices as licensees seek ways to better manage their spectrum resources and deliver a continuing stream of innovative services and applications.⁴ Over time, such use will grow naturally, driven by the competitive pressures of the market. Even with such promising prospects, however, the Commission must be careful not to rely on CRs to solve all the problems of spectrum efficiency and access. Despite the claims of some, CRs are not a panacea.⁵

From the comments, it is clear that CRs will be implemented in and impact radiocommunication services differently depending on frequency band and propagation characteristics, service type (fixed, mobile, broadcast, satellite, etc.), technologies and system architectures in use, current regulatory requirements, and numbers of incumbent end users. Given such differences, it is not surprising that many commenters believe that the deployment of CRs can only be effectively accomplished on a band-by-band (service-by-service) basis.⁶ Motorola summarizes the necessity of a band-specific approach:

³ See Comments of Cisco Systems, Inc. at 6; Comments of the Cellular Telecommunication and Internet Association ("CTIA") at 4-5; Comments of Verizon Wireless at 1, 3.

⁴ See Comments of Nokia, Inc., at 2; Comments of Cingular Wireless LLC/BellSouth Corporation ("Cingular") at 3-4.

⁵ See Comments of Motorola Inc. at 6; Cingular at 2. *But see* Comments of The Technology Companies generally. Unfortunately, The Technology Companies provide no real evidence to support their claims and assume away all technical difficulties with regard to putting CRs into licensed spectrum.

⁶ See Comments of Nokia at 2; Motorola at 6; Intel at 2-3; Cisco at 3 and 6.

[i]n determining whether it is practical to implement cognitive radio in any specific frequency band, it will be necessary to assess the situation on a band-specific basis because the viability and appropriate mechanisms for operation will vary on a band-by-band and service-by-service basis. It is not feasible to define criteria for cognitive radio broadly across all bands and services.⁷

Such differences make a “one size fits all” sharing approach extremely risky from an interference standpoint and certainly unwise from a public interest perspective.

II. UNLICENSED “NON-VOLUNTARY” COGNITIVE RADIOS SHOULD NOT BE PERMITTED TO OPERATE IN CMRS BANDS.

In this proceeding the Commission is attempting “to facilitate the improved spectrum use made possible by the emergence of the powerful real-time processing capabilities of cognitive radio technologies,” “while also seeking to maintain efficiency and reliability in spectrum use.”⁸ A critical part of the proceeding is thus to ensure that existing systems and users are not adversely affected by the introduction of CR technologies. The proposals in the *NPRM* regarding shared use of licensed spectrum, however, suffer from similar flaws as the Commission’s interference temperature concept, and would, if adopted, create interference to existing users.⁹ For this reason, the vast majority of commenters oppose the Commission’s “non-voluntary” scenario in which unlicensed CRs could access licensed spectrum at will and without coordination.¹⁰ AT&T Wireless agrees with The Technology Companies that future CRs be restricted so as to “create no harmful interference”¹¹

The basic assumptions in the *NPRM* are that unlicensed CRs will be able to sense accurately the presence of a licensed signal on a particular frequency (and not transmit in that

⁷ Comments of Motorola at 6.

⁸ *NPRM* at ¶¶ 5 and 2.

⁹ *Establishment of an Interference Temperature Metric to Quantify and Manage Interference and to Expand Available Unlicensed Operation in Certain Fixed, Mobile and Satellite Frequency Bands*, FCC 03-289, *Notice of Inquiry and Notice of Proposed Rulemaking*, ET Docket No. 03-237 (rel. Nov. 28, 2003) (“Interference Temperature *NOI/NPRM*”). AT&T Wireless respectfully requests that its comments in that proceeding, filed April 5, 2004, be made a part of this record.

¹⁰ See e.g., Comments of Wireless Communications Association, Inc. (“WCA”) at 2; Cingular at 5-10.

¹¹ Comments of The Technology Companies at 7. AT&T Wireless also appreciates The Technology Companies use of the quotation from Isaac Asimov’s *I, Robot*, even if it was not attributed.

case), and that they will cease transmitting if a licensed user begins to transmit on a frequency an unlicensed CR currently occupies. As the comments demonstrate, however, neither of these assumptions is defensible. In fact, in its recent *Notice of Proposed Rulemaking* on unlicensed use of broadcast spectrum, the Commission declined to propose spectrum sensing as the method by which unlicensed use of the broadcast bands would take place.¹² Contrary to the proposals in the instant *NPRM*, in the *Unlicensed Broadcast NPRM* the Commission appears to believe that a sensing approach *is not* adequate to “ensure” that interference to the incumbent licensed service can be avoided.

For the CMRS bands in particular, it appears that the only way to protect effectively users from interference is to prohibit CR use on a “non-voluntary” basis. In contrast to the broadcast bands, which represent one of the simpler cases in which a sensing method could be applied, the CMRS bands are characterized by hundreds of thousands of base stations and more than 160 million mobile transceivers. The Commission recognized the unique difficulties posed by mobility in the *Unlicensed Broadcast NPRM*, where it specifically proposed to exclude Private Land Mobile Radio Service (“PLMRS”) and CMRS channels from being used by unlicensed devices.¹³ In fact, the Commission went a step further and proposed not to allow unlicensed operations on either co- or adjacent channels within a specified distance from areas where PLMRS or CMRS systems operate.¹⁴ As Motorola notes: “[t]here are certain licensed bands and services that present unique challenges and which are not appropriate to consider for use by unlicensed cognitive devices. These include frequency bands used for mobile services, including the commercial mobile radio service, and frequency bands used for public safety services.”¹⁵ Based on the Commission’s own apparent concerns and more recent proposals, AT&T Wireless

¹² *Unlicensed Operation in the TV Broadcast Bands, Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band*, ET Docket No. 04-186, *Notice of Proposed Rulemaking* (rel. May 25, 2004) (“*Unlicensed Broadcast NPRM*”) at ¶ 21.

¹³ *Id.* at ¶ 35.

¹⁴ *Id.* at ¶ 36.

¹⁵ Comments of Motorola at 9.

urges it to reject unlicensed “non-voluntary” sharing in the CMRS bands and adopt a similar prohibition against unlicensed sharing in all the mobile bands; in no case should the Commission permit uncoordinated, unlicensed use of licensed spectrum by CRs in CMRS spectrum.

A. Uncoordinated Unlicensed Devices Will Cause Interference.

It is clear from the comments that CRs—as “smart” as they are—cannot overcome the fundamentals of physics. The Commission’s proposals—as was the case in the interference temperature context—largely fail to account for the complexities encountered in practical engineering and real world circumstances.¹⁶ First, the Commission’s belief that CRs can accurately sense the presence of a licensed signal in order to make a transmit/no transmit decision is unfounded for several reasons. Most basically, it fails to account for the fact that CRs will not be collocated with victim receivers and so would not be able to accurately judge if there was a signal present at the victim receiver’s actual location.¹⁷ CR sensors would only be able to read the radio environment of their immediate surroundings based on their own antenna and receiver characteristics. As a result,

even where a cognitive radio knows that a given frequency is not being used at its location, that evaluation will say nothing about whether the frequency is being used and received at licensed receivers in other areas that the cognitive radio must protect. This means there will be incalculable situations where a cognitive radio perceives that it is permitted to transmit when in fact its transmission will actually cause interference at licensed receivers.¹⁸

The fundamental problem stems from the fact that the radio environment can vary considerably from location to location, depending on a number of factors including: distance from transmitters, multi-path signal fading, and penetration through walls, partitions, buildings, foliage, and other factors.

¹⁶ See Comments of Motorola at 10.

¹⁷ See e.g., Comments of AT&T Wireless Services, Inc., ET Docket No. 03-237 (filed April 5, 2004); Comments of Intel Corporation at 9 noting that “it is unclear if the sensing method is feasible... Assumptions about the environment at potential victim receivers based on measurements at the transmitter may not be appropriate. Accordingly, Intel believes the proposed change [increased transmitter power] should not be made unless this concern is adequately addressed.” See also Comments of Ericsson, Inc., at 15-16; Comments of Cisco at 8-9.

¹⁸ Comments of WCA at 8.

These localized differences can prevent a[n unlicensed] transmitter from determining interference conditions at the receivers [that] the transmissions might affect. Frequency selection based on RF energy measurements -- even if these can detect signals below the local noise level -- may not be sufficient to determine a choice of operating frequency. Therefore, in some cases, it may be necessary to develop a service-specific sharing regime in addition to frequency agility.¹⁹

In fact, in the CMRS context at least, the case is more difficult than even Cisco appears to realize. With multiple CMRS technologies being used that have widely varying technical and signal characteristics; air-interface specific sharing would have to be negotiated. Furthermore, in CMRS systems, where devices are constantly in motion, reliable detection would be an even more difficult challenge as licensed devices come into and out of an unlicensed devices interference zone.²⁰ In this case, a spectrum sharing regime such as Cisco suggests would be best left to the individual licensees to negotiate as part of a secondary markets approach (see *infra* section III. A).

Moreover, there are numerous other factors that would result in “false positive” indications of spectrum availability. The most common problem in this regard is the “hidden node/transmitter” problem where a CR would not be able to sense the presence of a licensed transmitter due to terrain, buildings or other types of signal blocking and begins transmitting—causing interference to a nearby receiver that is receiving its licensed signal on the same frequency.²¹ The Commission specifically noted this difficulty in the *Unlicensed Broadcast NPRM*, and is presumably one of the reasons the Commission declined to propose spectrum sensing as an appropriate method for sharing spectrum between broadcast and unlicensed users.²²

Unfortunately, cyclostationary detectors, which the Commission believes may alleviate this problem, may not be effective.²³ The *NPRM* notes, for example, that such detectors require

¹⁹ Comments of Cisco at 9 (footnotes omitted).

²⁰ See Comments of Ericsson at 16.

²¹ See e.g. Comments of Verizon at 4; Motorola at 11-12; WCA at 8-9; Cingular at 9.

²² *Unlicensed Broadcast NPRM* at ¶ 20, fn 34.

²³ See Comments of New York State Office for Technology at 8; Cingular at 14-15.

knowledge of the signal format in order to work.²⁴ In the CMRS bands, that will entail loading signal profiles for all the existing carriers and all their technologies and assuming the CR device could apply the right format at the right time. In addition, new formats would have to be learned as carriers deploy new technologies. Texas Instruments summarizes: “there is no way to assure incumbent licensees of the effectiveness of this technology in protecting their specific receivers from interference. Moreover, detecting transmissions is only effective in protecting receivers when transmitters and receivers are both collocated and co-channel, but may not help with adjacent channel interference issues or receive-only sites.”²⁵ The Commission itself appears to have doubts about the effectiveness of such detectors; the *Unlicensed Broadcast NPRM* asks for specific comment on how the “hidden node” problem can be solved if a sensing approach is taken—without mentioning cyclostationary detectors.²⁶

Similarly, a CR device out of range of the CMRS base station coverage area (or within the general coverage area, but in poor signal strength environment such as in buildings, urban canyons, or other types of coverage holes) would not be able to assess correctly spectrum availability at the licensed receiver’s location. Its transmission would cause interference to nearby mobile station that is within the base station coverage area.

Finally, it is clear from the comments that dynamic frequency selection (“DFS”), even generically defined, is not a solution that is applicable across bands and services. DFS was developed based on the specific needs and unique systems in the 5.8 GHz band. As Cisco notes: “[a]lthough the basic concept of DFS could in theory be used in other frequency bands, it would require all new studies to determine not only if DFS could detect the various signals of other

²⁴ *NPRM* at ¶25.

²⁵ Comments of Texas Instruments at 6. Texas Instrument’s solution, the use of a common control channel, does not appear to be a practical alternative. It relies on the same flawed detection techniques and then adds additional overhead in the form of all the communications needed to negotiate channel use. It also presumes operators will completely rebuild their infrastructures and replace all their radios in order to share their spectrum—despite the complete lack of incentives to do so.

²⁶ *Unlicensed Broadcast NPRM* at ¶ 28.

services in other bands but also to determine what detection thresholds would be needed.”²⁷

Furthermore, several commenters point out that a DFS solution may be especially ill-suited to environments where the primary licensed service is mobile, like CMRS.²⁸

B. Reversion Mechanisms Are Not Known And Risks Are High.

The second part of the interference problem in a shared licensed/unlicensed environment is: what happens when a licensed signal starts transmitting on a frequency (band) occupied by an unlicensed CR? When and how quickly would the unlicensed device stop transmitting and/or switch to another frequency?²⁹ The difficulty is that a transmitting CR may be unable to detect that a primary spectrum user has begun transmitting. Many devices are not able to transmit and receive on the same frequency at the same time; even devices that employ time division duplex operation do not transmit and receive simultaneously.

In this circumstance, two possibilities arise; both of which degrade the licensed network. In the first case, the licensed network may avoid using a particular channel if there is interference. CMRS technologies, for example, utilize real time measurements of the radio spectrum, and block or hand over radio channels that experience interference above a defined threshold. Examples include interference detection and evaluation on call assignment and handover on bit error rate in GSM systems. In essence, the unlicensed device would hijack the channel once it begins transmitting (for as long as it continues to transmit). As a result, end users may experience failed system access or call setup attempts.³⁰ In the second case, the licensed system does assign and begins to transmit on the (already-occupied) channel, unaware that the receiver is situated near a CR device transmitting on the same frequency. The result is co-channel interference resulting in either poor link quality or in the case of CMRS, a forced hand-off to another channel—reducing overall cell/network capacity. Nor does it appear possible to develop a

²⁷ Comments of Cisco at 8.

²⁸ See Motorola at 10-11; Ericsson at 4; Cingular at 12-13.

²⁹ See Comments of WCA p. 5.

³⁰ See Comments of National Public Safety Telecommunications Council (“NPSTC”) at 14; Comments of Industrial Telecommunications Association, Inc. (“ITA”) at 4.

reliable statistical model that could accurately predict CMRS individual channel use, making it “very difficult, if not impossible for the CR to predict when primary user activity will be initiated or resume on the channel.”³¹ The Commission has provided no proposals for reversion mechanisms that would work in a “non-voluntary” sharing of licensed and unlicensed CR users, and no viable solutions have been suggested to solve the problem.³²

The cumulative effect of uncoordinated CRs operating in a given area would be to decrease the quality and reliability of CMRS networks.³³ If a CR fails to sense the presence of a radio signal on a particular channel and begins to transmit, or fails to release a channel the licensed system needs, its transmission would increase the interference on the licensed radio channels. Given the interference threat, and until viable solutions to these problems can be developed, AT&T Wireless urges the Commission not to permit “non-voluntary” CR operation in the CMRS bands.

III. SPECTRUM ACCESS AND COGNITIVE RADIO DEVELOPMENT ARE BEST PROMOTED THROUGH SECONDARY MARKET MECHANISMS AND ENHANCED USE OF UNLICENSED SPECTRUM.

A. Secondary Market Arrangements Would Best Enhance Spectrum Access in Licensed Spectrum.

In contrast to the near universal opposition to forced sharing, there is a high level of agreement that secondary market approaches would be the best way to move forward with the development and implementation of CRs.³⁴ Numerous commenters note that licensees have

³¹ Comments of Motorola at 12. *Id.* at 12 noting that “it may be possible to compile statistics on the time between assignments and predict to a certain confidence when the primary user will be access the channel, but the statistics would not necessarily be stationary and even if they were, there are still bound to be cases where the prediction fails miserably.”

³² See Comments of Cisco at 11 suggesting that CRs simply “turn off transmissions in the event that the device is causing harmful interference.” While this might be an appropriate solution, Cisco does not explain how the device would know it is interfering, nor discuss the timing of such shut off, the need for which will vary by licensed technology. See also Comments of WCA at 5 noting the lack of technical solutions.

³³ See Comments of Nokia at 2-3; CTIA at 2.

³⁴ See Comments of CTIA at 7-8; WCA at 11-15; Access Spectrum LLC generally; Motorola at 14-15; Nokia at 4.

incentives to maximize their use of spectrum as long as such use makes economic sense.³⁵ The Spectrum Policy Task Force Report recognizes this fact as well, observing that “licensees have economic incentives to use spectrum in ways that will yield the highest return to them,” and they generally will grant others access to unused portions of their spectrum “if they are adequately compensated.”³⁶ The keen interest in the Commission’s Secondary Markets proceeding is evidence that licensees are motivated to extract the most value out of their spectrum—whether by increasing their own efficiency or by leasing access to others. In reality, both courses are pursued; increased efficiency can free up more spectrum for lease, thereby bringing in additional revenues to the licensee. Conversely, as Verizon points out, “[a] licensee facing greater interference from unlicensed transmitters will have less incentive and ability to resell spectrum.”³⁷

The key element for increasing the efficiency of licensed spectrum—and the development of cognitive radios in it—is to ensure that the licensee retains full control over that spectrum. Such control would be essential to prevent interference to licensed users and to ensure that existing quality of service levels can be maintained.³⁸ Although AT&T Wireless continues to believe that the technical difficulties noted above make uncoordinated, unlicensed CR use unworkable in the CMRS bands, it may one day be possible that licensed and unlicensed devices could share spectrum under circumstances specified and carefully controlled by the licensee. In that case, where the licensee retains total control over the operations of its licensed devices and the operations of the unlicensed CR devices, common management might be able to avoid interference.³⁹ A secondary markets approach would allow the licensee and the prospective user to craft optimum sharing arrangements, if possible, based on the licensee’s system and the CR

³⁵ See Comments CTIA at 8; Access Spectrum LLC at 2; Cingular at 4.

³⁶ Spectrum Policy Task Force, ET Docket No. 02-135, Report (rel. Nov. 15, 2002) at 57.

³⁷ Comments of Verizon at 10.

³⁸ See Comments of Access Spectrum LLC at 3; Motorola at 14; Cingular at 4.

³⁹ AT&T Wireless notes, however, that past experiments with a similar concept, Cellular Digital Packet Data, were not successful.

technology.⁴⁰ The Commission has neither the need nor the resources to insert itself in such discussions, and in any case could never define generic technical rules that would cover all the different combinations of CMRS and unlicensed technologies. AT&T Wireless thus joins those urging the Commission to clarify that licensees have full rights—and responsibilities—to control their spectrum, and also to allow licensees and unlicensed users to enter contractual arrangements for spectrum sharing based on CR technology.⁴¹

B. Unlicensed Cognitive Radios Should Be Developed in Unlicensed Bands.

One thing on which many commenters agree is that additional spectrum should be identified for unlicensed use.⁴² “This is the ‘holy grail’ for intelligent devices, and must be in the regulatory endgame if they are to reach their fill [sic] potential to maximize spectrum use...It is imperative that the Commission continue to dedicate spectrum to common use.”⁴³ AT&T Wireless has consistently supported such an approach, and the comments in this proceeding only reinforce its belief that the development and testing of unlicensed devices—including those having cognitive capabilities—should be confined to bands identified specifically for unlicensed use.

IV. HIGHER POWER FOR UNLICENSED COGNITIVE RADIOS NEEDS FURTHER STUDY.

Although AT&T Wireless supports the Commission’s desire to improve spectrum access in rural and other underserved areas, the proposals in the *NPRM* do not appear to offer the most effective approach. In fact, judging by the comments, raising power levels in the manner the Commission suggests may actually do more harm than good.

⁴⁰ See Comments of WCA at 14; Motorola at 14; Cingular at 4.

⁴¹ See Comments of Verizon at 10; Access Spectrum LLC at 4.

⁴² See e.g., Motorola at 7; The Technology Companies at 8; Cingular at 9 and 16-18.

⁴³ Comments of The Technology Companies at 8.

As an initial matter, AT&T Wireless strongly opposes an across-the-board rise in unlicensed power levels under section 15.209.⁴⁴ As AT&T Wireless argued with respect to the interference temperature concept, permitting the power level of unlicensed devices to rise—either to a new fixed point, as the Commission proposes here, or to a vaguely-defined interference temperature limit—will inject additional external power into the band and effectively reallocate spectral resources from licensed users to unlicensed devices.⁴⁵ Further, AT&T Wireless and other commenters in the interference temperature proceeding detailed the impacts of a rise in the interference temperature on coverage, capacity, and service quality.⁴⁶ In this proceeding, the Commission asks “whether these power increases are likely to result in interference to other users;”⁴⁷ but has already answered its own question in the Interference Temperature *NOI/NPRM*, where Figure 1 graphically shows the result of an increase in interference.⁴⁸ The case is no different here: unlicensed devices operating at higher power will rob licensees of coverage and capacity.⁴⁹ The impact would be especially noticeable at cell edges; potentially in those same rural areas where the Commission is trying to promote access.⁵⁰

In addition, AT&T Wireless also has several concerns with the Commission’s proposal to permit higher power under sections 15.247 and 15.249 in areas with “limited spectrum use.”⁵¹ First, higher power will increase interference to adjacent bands. Because no changes are proposed to out of band emissions (“OOBE”) and the fact that OOBE are tied to in-band power, the amount of energy spilling into adjacent bands will rise.⁵² A simple increase in output power would increase power in all dimensions and thus increase the likelihood of both internal and external interference. AT&T Wireless is particularly concerned with the potential impacts on the

⁴⁴ *NPRM*, 18 FCC Rcd at 26874, ¶ 41.

⁴⁵ See Comments of AT&T Wireless, *Interference Temperature NOI/NPRM* at 23.

⁴⁶ See e.g. Comments of Verizon Wireless; Comments of V-Comm; Comments of Sprint Corporation; Comments of Cingular Wireless LLC and BellSouth Corporation, *Interference Temperature NOI/NPRM*.

⁴⁷ *NPRM*, 18 FCC Rcd at 26874, ¶ 41.

⁴⁸ *Interference Temperature NOI/NPRM* ¶ 15.

⁴⁹ See Comments of CTIA at 5-6; Nokia at 3.

⁵⁰ See Comments of Nokia at 3; CTIA at 8.

⁵¹ *NPRM*, 18 FCC Rcd at 26874, ¶¶ 36-40.

⁵² See Comments of Ericsson at 16-17; CTIA at 8; Cingular at 20.

cellular bands, which are just below the 900 MHz unlicensed spectrum, and the Wireless Communications Service bands, which are just below the 2.4 GHz ISM band. In addition, the impacts on the 2500-2690 MHz band, for which technical rules are still under consideration, should be studied before raising the power limit in the 2.4 GHz band. AWS thus agrees with WCA and others that the Commission's rules "must be modified to assure that out-of-band emissions are not increased above the current maximum level even if unlicensed facilities are permitted to operate at higher power under the Commission's proposal."⁵³

Second, as several commenters point out, the definitions of "rural," "unused spectrum," and "limited spectrum use" are unclear at best and misleading at worst.⁵⁴ Indeed, the concept of "unused" is somewhat strangely defined in the *NPRM*. Rather than identifying spectrum that is truly unused, the Commission appears to be seeking out spectrum that is just not used very much—places where there is "limited spectrum use," defined as "spectrum with a measured aggregate noise plus interference power no greater than 30 dB above the calculated thermal noise floor within a measurement bandwidth of 1.25 MHz."⁵⁵ As several commenters point out, it is unclear why these specific criteria were chosen or how exactly the required measurement regime would work in practice.⁵⁶ The most serious deficiency with the definition, however, is that it falls victim to the same conceptual and practical problems that plague the interference temperature concept, namely that spectrum must be monitored to determine its use (and the level of use).⁵⁷

Most troubling about the proposals to raise power limits is that, despite the *NPRM*'s focus on improving services and access in rural areas, which AT&T Wireless supports, it is clear that the Commission's proposal goes far beyond rural areas—with correspondingly more

⁵³ Comments of WCA at 17. *See also* Comments of CTIA at 9.

⁵⁴ *See* Comments of Alvarion at 4; Cingular at 21-23.

⁵⁵ *NPRM* at ¶44. Cingular at 21 points out that this definition appears to be inconsistent with the actual proposed rule in Appendix A of the *NPRM*.

⁵⁶ *See* Cingular at 21-23; Motorola at 8 noting that the definition "does not have a substantive basis."

⁵⁷ *See infra* at section II.A; Comments of Nokia at 3.

widespread, and serious, implications.⁵⁸ Rather than seeking to define “rural” in geographic terms as proposed in the *Rural NPRM*,⁵⁹ or providing a suitable definition that would tailor the solution to best serve the needs of rural America, the Commission instead proposes to allow higher power “in any area that has limited spectrum use.”⁶⁰ This leap—from rural areas to any area with limited spectrum use—is unwarranted and unjustified. By overextending the scope of the “solution” and continuing to rely on the same flawed technological assumptions regarding measurement that characterize the interference temperature concept, the Commission risks creating more problems than it seeks to solve, especially in terms of the potential interference to a much wider user base—in both licensed and unlicensed services.

If, despite the comments and concerns noted above regarding the effects of increased power, the Commission does indeed decide to raise power limits for unlicensed CRs, it should adopt its alternative geo-location proposal.⁶¹ Consequently, AT&T Wireless urges the Commission to drop the “limited spectrum use” model in favor of a rural definition more suited to the task at hand, and one that is consistent with the rules adopted in response to the *Rural NPRM*.⁶² Such use could serve as a test bed allowing the Commission, licensees, and unlicensed users to evaluate the benefits and disadvantages of the increase in a real-world setting.

Third, AT&T Wireless shares the concerns of those commenters who express doubts about the long-term effectiveness of raising power limits and concern about the impact on

⁵⁸ NPSTC at 13, for example, is concerned that high power unlicensed devices would migrate outside rural areas and cause interference in metropolitan markets.

⁵⁹ *Facilitating the Provision of Spectrum-Based Services to Rural Areas and Promoting Opportunities for Rural Telephone Companies To Provide Spectrum-Based Services, Notice of Proposed Rulemaking*, WT 02-381, *Notice of Proposed Rulemaking*, FCC 03-222 (rel. Oct. 6, 2003) (“*Rural NPRM*”) at ¶¶ 10-12.

⁶⁰ *NPRM* at ¶ 36. AT&T Wireless notes that the *NPRM*’s discussion of geo-location for rural systems (¶47) appears to conflict with the definition of unused spectrum as “limited spectrum use.” Since that definition is not geographically bounded, technologies such as GPS are irrelevant in that context.

⁶¹ *NPRM* at ¶47.

⁶² AT&T Wireless notes that the *Rural NPRM* asks if different definitions of “rural” are appropriate to serve different policy objectives. Since both proceedings seek to promote access to the same service, wireless broadband services, the question is moot in this case. Such services require a consistent definition, regardless of whether the service is provided on licensed or unlicensed spectrum. Moreover, the participants in the Commission’s recent Wireless Broadband Forum (May 19, 2004) made clear that individual service providers will indeed use both licensed and unlicensed spectrum. Providing inconsistent or conflicting definitions would only serve to confuse both those licensees and the market.

existing lower power devices that currently occupy the bands.⁶³ Overall, it is likely that raising the power limits would lead to higher levels of interference.⁶⁴ In addition, there is a strong possibility that “power wars” will erupt. Once one user raised power, others would be forced to follow suit in order to maintain their own communications integrity and reliability. In addition, even if raising the power benefits those who seek to provide point to point or point to multipoint services, the impacts on the existing users of the bands could be severe as the performance of lower power devices, like WiFi and other applications that operate near the noise floor is reduced.⁶⁵ The current success of the unlicensed bands is largely due to their low power and ability to avoid widespread interference. Making hasty changes to the fundamental element in that formula—low power—could undermine the success the unlicensed industry has achieved to date.

As an alternative to the Commission’s proposed approach to raising power limits, AT&T Wireless supports relaxing restrictions in the existing rules to allow higher EIRP output power limits.⁶⁶ This change will enable reliable communications in rural areas without increasing interference to others. Thus, AT&T Wireless agrees with Cingular that the “Commission should make clear that any increase in power for unlicensed spread-spectrum devices in areas of limited spectrum use will be limited to changing the system’s antenna gain (and thus its EIRP) and

⁶³ See Comments of Itron, Inc. generally; Cingular at 18-21 and 24.

⁶⁴ See Comments of Comments of Information Technology Industry Council (“ITIC”) at 11; Intel at 4.

⁶⁵ See Comments of WCA at 16 noting the below noise floor impacts; Itron at 2-4 detailing the specific impacts on the 902-928 MHz band.

⁶⁶ See Comments of Wireless Broadband Operators Coalition (“Broadband Coalition”) at 6-7. However, AT&T Wireless opposes the Broadband Coalition’s other proposal to redefine power limits as proposed in section 15.249 (b) in terms of maximum average interference power (“MAIP”) rather than maximum peak output power.⁶⁶ This methodology could result in higher interference to licensed adjacent bands especially from unlicensed devices with a low transmit duty cycle. Validation of the MAIP concept and analysis of the impacts of such a modification are required before any change is made to the existing definition power limit definition. In any case, it is critical that the Commission ensure that any change in the power limits in the unlicensed bands not increase the absolute amount of OOB from unlicensed operations into adjacent licensed spectrum than that allowed by the current maximum levels.

should affirmatively state that the output power of the unlicensed device and the level of out-of-band emissions does not increase.”⁶⁷

The comments indicate that significant questions remain to be answered before the Commission can raise the power limits for unlicensed devices in the 900 MHz, 2.4 GHz and 5 GHz bands.⁶⁸ In no case should the Commission raise the power limits under section 15.209. To improve unlicensed spectrum use in rural areas, AT&T Wireless recommends that the Commission take the following steps: first, gather additional information on the specific effects of increased power levels on both other unlicensed devices sharing the bands and on services in adjacent bands.⁶⁹ This could include, at a minimum, studies modeling the effects of such a rise. Second, using this data, consider whether raising EIRP, rather than power, is a more appropriate way forward. AWS agrees with Cingular that such issues should be the focus of a Further Notice of Proposed Rulemaking. Third, adopt any changes only if combined with a definition of rural area that is consistent with that developed in the *Rural Services* proceeding.

V. SECURITY ISSUES WILL BE CRITICAL TO THE SUCCESSFUL FUNCTIONING OF COGNITIVE RADIOS AND SHOULD BE LEFT TO INDUSTRY FOR NOW.

Like the Commission, AT&T Wireless is extremely “concerned about the potential for parties to make unauthorized changes to software programmable radios after they are manufactured and first sold which could result in harmful interference to authorized services.”⁷⁰ The source of AT&T Wireless’s concern is inherent in the nature of the SDRs themselves—the ability to change operating parameters. It is conceivable that (in either a voluntary or non-voluntary sharing scenario) a user could alter the operating parameters of a device in ways that

⁶⁷ Comments of Cingular at 20.

⁶⁸ See Comments of Satellite Companies at 3.

⁶⁹ See Comments of ITIC at 11 noting that “little technical work or real-world testing on the impact of higher-power operation has been conducted in the 900 MHz and 2.4 GHz bands.”

⁷⁰ NPRM at ¶ 84.

would cause interference or that would harm the operation of the licensed network.⁷¹ For example, the device could be altered to operate with higher transmit power, causing interference to the licensed users; or a user could alter the device to “squat” on a frequency. What is particularly troubling is that the user could change the device back to its “approved” state, and no one would be the wiser. Enforcement would be extremely difficult, if not impossible.⁷²

This ability implies that whatever changes the Commission makes to the certification and testing process may be of limited value if the operation of the radio can subsequently be changed such that it is out of compliance with Commission rules. Under such circumstances, the potential for interference would be high despite the Commission’s best intentions. WCA correctly points out that the situation is even more potentially threatening to licensed users if unlicensed devices can be built to operate in bands not even authorized for such use in the United States.⁷³ Given these circumstances, it is clear that extensive security measures should be incorporated in the devices to prevent unauthorized changes.

However, while AT&T Wireless would like to see strong security requirements adopted by the Commission, it is unclear how such requirements could best be developed and triggered in today’s rapidly changing technology climate. In particular, although forcing mandatory declaration of a device as an SDR, and thus imposing security requirements on it, has its appeal to an operator trying to protect its network, it is unclear how effective such an approach would actually be and whether the disadvantages would outweigh the benefits. AT&T Wireless concurs with NPSTC that

[t]he problem is not whether the device is an SDR or not, but rather, the concern and challenge is whether any device capable of remotely modifying parameters via software after manufacture is provided with adequate security to prevent

⁷¹ See Comments of ITA at 5.

⁷² See Comments of ITA at 6; CTIA at 9-11.

⁷³ See Comments of WCA at 7-8; *Id.* at 9 noting that “[t]he equipment certification process simply cannot be depended on to regulate or guarantee how cognitive radio users behave once their devices have been certified and have entered the marketplace.”

unauthorized changes, to prevent the use of unapproved software, and to protect against interference, be it accidental, malicious, malfunction or other cause.⁷⁴

Cingular raises similar concerns, noting that security methods are needed to prevent unauthorized modifications to a device that “is capable of being remotely programmed.”⁷⁵

Reluctantly, AT&T Wireless agrees with those commenters who note that the technology of SDRs and CRs is still at a nascent stage and that imposing burdensome requirements could unintentionally steer technology developments and potentially circumscribe advancements that would be beneficial.⁷⁶ Regardless of what the Commission ultimately decides on mandatory declaration of SDRs, AT&T Wireless concurs with those commenters who recommend that the necessary security solutions be developed in industry-led standards development organizations.⁷⁷ Ultimately, AT&T Wireless is not fully convinced that existing safeguards are adequate and urges the Commission to continue to monitor the deployment of CRs in the marketplace and to act swiftly if evidence of unauthorized changes begins to mount.

CONCLUSION

It is clear from the comments that a host of technical and legal questions still must be answered before unlicensed CR technologies are ready for widespread deployment in support of unlicensed applications. Such technologies are still in the early development stages, and have not been proven to be either technically or economically viable, particularly when sharing spectrum with licensed services. In no circumstance should “non-voluntary” sharing be forced on CMRS carriers, who are already using CR technology to maximize their use of spectrum. If sharing between licensed services and unlicensed CRs becomes possible through mechanisms controlled

⁷⁴ Comments of NPSTC at 19. In this regard, AT&T Wireless notes that the proposal by Intel at 5 (which otherwise opposes mandatory declaration for SDRs) to impose “SDR requirements on those devices where the manufacture[r] intends to allow modifications in the field” is well-meaning, but incomplete. Although AT&T Wireless appreciates Intel’s attempt to improve security, it makes no difference what the maker’s *intent* is, only what can be done with the radio once it leaves the factory. As NPSTC notes, adequate security features will be needed on all SDRs, not just those declared as SDRs or intended to be modified.

⁷⁵ Cingular at 27.

⁷⁶ See Comments of Motorola at 19; NPSTC at 19; Intel at 3; Ericsson at 20. *But see* Cisco at 12, noting that reprogrammable SDRs should be required to file as such.

⁷⁷ See Comments of NPSTC at 22; Intel at 3; Cingular at 28.

by the licensee, the parties should be allowed to execute a contractual arrangement according to the secondary market principles the Commission has adopted. Such an approach would allow the existing licensed operator to maximize its own use of its spectrum, while allowing secondary users access if a convincing technical and business case can be made. At this time, AT&T Wireless believes that it is premature to adopt higher power limits for unlicensed CR devices or to require SDR manufacturers to declare their devices as such. AT&T Wireless, however, does support continued Commission scrutiny to ensure that end user devices may not be modified without proper verification and authorization.

Respectfully submitted,

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/s/

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